(19) Europäisch s Patentamt
European Patent Offic
Offic eur péen des brevets

(11) EP 0 617 164 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
13.08.1997 Bulletin 1997/33

(51) Int Cl.6: D21F 11/14

(21) Application number: 94104623.7

(22) Date of filing: 23.03.1994

(54) **Method for making smooth uncreped throughdried sheets**

Verfahren zur Herstellung von sanften, ungekreppten, durchblasgetrockneten Blättern

Procédé de fabrication de feuilles douces, non-crêpées, séchées par traversée d'air

(84) Designated Contracting States:
BE DE ES FR GB IT NL SE

(30) Priority: 24.03.1993 US 36649

(43) Date of publication of application:
28.09.1994 Bulletin 1994/39

(73) Proprietor: KIMBERLY-CLARK CORPORATION
Neenah, Wisconsin 54956-0349 (US)

(72) Inventors:
- Hyland, David Arthur
Hawarden, Clwyd (GB)
- Engel, Steven Alexander
Neenah, Wisconsin 54956 (US)
- Sudall, Stephen John
Ruthin, Clwyd LL15 1YR, Wales (GB)
- Williams, Paul Edward
Neenah, Wisconsin 54956 (US)

(74) Representative:
Diehl, Hermann, Dr. Dipl.-Phys. et al
DIEHL, GLÄSER, HILTL & PARTNER
Patentanwälte
Flüggenstrasse 13
80639 München (DE)

(56) References cited:
EP-A- 0 342 646
US-A- 4 440 597
US-A- 4 849 054

EP 0 617 164 B1

Printed by Jouve, 75001 PARIS (FR)

Description

In the manufacture of paper products such as towels, wipers and the like, a wide variety of product characteristics must be given attention in order to provide a final product with the appropriate blend of attributes suitable for the product's intended purpose. Among these various attributes, improving surface feel, strength, absorbency, bulk and stretch have always been major objectives. Traditionally, many of these paper products have been made using a wet-pressing process in which a significant amount of water is removed from a wet laid web by pressing or squeezing water from the web prior to final drying. In particular, while supported by an absorbent papermaking felt, the web is squeezed between the felt and the surface of a rotating heated cylinder (Yankee dryer) using a pressure roll as the web is transferred to the surface of the Yankee dryer for final drying. The dried web is thereafter dislodged from the Yankee dryer with a doctor blade (creping), which serves to partially debond the dried web by breaking many of the bonds previously formed during the wet-pressing stages of the process. Creping can greatly improve the feel of the web, but at the expense of a significant loss in strength.

A method for forming a paper web from an aqueous slurry of papermaking fibers, using a Yankee dryer is disclosed in US-A-4,440,597. According to this document, a web of low fiber consistency is forwarded on a foraminous member to a differential velocity transfer zone. Subsequent to said transfer, the web is dried by aid of a Yankee dryer. A further method using a Yankee dryer is described in US-A-4,849,054. Said document describes the manufacture of a fibrous sheet material.

More recently, throughdrying has become an alternate means of drying paper webs. Throughdrying provides a relatively noncompressive method of removing water from the web by passing hot air through the web until it is dry. More specifically, a wet-laid web is transferred from the forming fabric to a coarse, highly permeable throughdrying fabric and retained on the throughdrying fabric until dry. The resulting dried web is softer and bulkier than a conventionally-dried uncreped sheet because fewer bonds are formed and because the web is less compressed. Squeezing water from the wet web is eliminated, although the use of a pressure roll to subsequently transfer the web to a Yankee dryer for creping may still be used. EP-A-0342646 describes a method for making hand or wiper towels using a throughdryer belt for non-compressively drying the towels.

While there is a processing incentive to eliminate the Yankee dryer and make an uncreped throughdried product, uncreped throughdried sheets are typically quite harsh and rough to the touch compared to their creped counterparts. This is partially due to the inherently high stiffness and strength of an uncreped sheet, but is also in part due to the coarseness of the throughdrying fabric onto which the wet web is conformed and dried.

Therefore there is a need for a method for making an uncreped throughdried paper web which can provide improved combinations of sheet properties for a variety of different products.

This object is solved by the method of making a cellulosic web according to independent claim 1 or 9. Further advantageous features, aspects and details of the invention are evident from the dependent claims, the description, examples and drawings.

It has now been discovered that an improved uncreped throughdried web can be made by transferring the wet web from a forming fabric to one or more intermediate transfer fabrics before further transferring the web to the throughdrying fabric for drying of the web. The intermediate transfer fabric(s) is(are) travelling at a slower speed than the forming fabric during the transfer in order to impart stretch into the sheet. As the speed differential between the forming fabric and the slower transfer fabric is increased (sometimes referred to as "negative draw" or "rush transfer"), the stretch imparted to the web during transfer is also increased. The transfer fabric can be relatively smooth and dense compared to the coarse weave of a typical throughdrying fabric, but preferably is not as smooth as the forming fabric in order to provide some degree of friction to grip the web during transfer. Gripping of the web is accomplished by the presence of knuckles on the surface of the transfer fabric. In addition, it can be advantageous if one or more of the wet web transfers, with or without the presence of a transfer fabric, are achieved using a "fixed gap" transfer which will be hereinafter described in detail. The fixed gap transfer not only avoids compaction of the web while it is in a wet bond-forming state, but when used in combination with a differential speed transfer and/or a smooth transfer fabric, is believed to smooth out the surface of the web by scuffing its surface during the transfer.

Hence, in one aspect the invention resides in a method of making a noncompressively-dried cellulosic web comprising: (a) depositing an aqueous suspension of papermaking fibers onto the surface of an endless travelling foraminous forming fabric to form a wet web having a consistency of from about 15 to about 25 weight percent; (b) transferring the wet web to a transfer fabric (hereinafter described) travelling at a speed from about 5 to about 75 percent slower than the forming fabric to impart stretch into the web; and (c) transferring the web to a drying fabric, preferably a throughdrying fabric, whereon the web is dried to final dryness in an uncreped state. This method provides a means for producing webs with improved smoothness, stretch and relatively high caliper or thickness, as measured from one side of the web to another, particularly at relatively low basis weights. It is preferred that in transferring the web from one fabric to another, the transfer be carried out with a fixed gap between the two fabrics having a span equal to or greater than the thickness or caliper of the web so that the web is not compressed.

In another aspect, the invention resides in a method of making a noncompressively-dried cellulosic web comprising: (a) depositing an aqueous suspension of papermaking fibers onto the surface of an endless travelling foraminous forming fabric to form a wet web having a consistency of from about 15 to about 25 weight percent; (b) transferring the wet web to a drying fabric, preferably a throughdrying fabric, travelling at a speed from about 5 to about 75 percent slower than the forming fabric while maintaining a fixed gap between the forming fabric and the drying fabric; and (c) noncompressively drying the web.

In a further aspect, the invention resides in an uncreped, uncalendered throughdried cellulosic web having a Surface Smoothness (hereinafter defined and described in connection with Figure 3) of about 81.3μm (about 3200 micro-inches) or less, preferably about 63.5μm (about 2500 micro-inches) or less, and more preferably about 38.1μm (about 1500 micro-inches) or less. As hereinafter described, increased smoothness is achieved through the use of the transfer fabric and, preferably, in combination with a fixed gap carrier fabric section following drying. Calendering of the web is not necessary to obtain these levels of smoothness, although it is within the scope of this invention that the smooth webs of this invention be further processed to further enhance the properties of the sheet, such as by calendering, embossing or creping.

The forming process and tackle can be conventional as is well known in the papermaking industry. Such formation processes include Fourdrinier, roof formers (such as suction breast roll), and gap formers (such as twin wire formers, crescent formers) etc. Forming wires or fabrics can also be conventional, the finer weaves with greater fiber support being preferred to produce a more smooth sheet or web. Headboxes used to deposit the fibers onto the forming fabric can be layered or nonlayered.

The basis weights of the webs of this invention can be any weight suitable for use as a paper towel or wiper. Such webs can have a basis weight of from about 15 to about 60 grams per square meter, more suitably from about 20 to about 30 grams per square meter.

As used herein, "transfer fabric" is a fabric which is positioned between the forming section and the drying section of the web manufacturing process. Suitable transfer fabrics are those papermaking fabrics which provide a high fiber support index and provide a good vacuum seal to maximize fabric/sheet contact during transfer from the forming fabric. The fabric can have a relatively smooth surface contour to impart smoothness to the web, yet must have enough texture to grab the web and maintain contact during a rush transfer. Finer fabrics can produce a higher degree of stretch in the web, which is desireable for some product applications.

Transfer fabrics include single-layer, multi-layer, or composite permeable structures. Preferred fabrics have at least some of the following characteristics: (1) On the side of the transfer fabric that is in contact with the wet web (the top side), the number of machine direction (MD) strands per cm (inch) (mesh) is from 3.94 to 78.74 cm (10 to 200) and the number of cross-machine direction (CD) strands per cm (inch) (count) is also from 3.94 to 78.74 cm (10 to 200). The strand diameter is typically smaller than 0.127 cm (0.050 inch); (2) On the top side, the distance between the highest point of the MD knuckle and the highest point of the CD knuckle is from about 0.00254 to about 0.0508 or 0.0762 cm (about 0.001 to about 0.02 or 0.03 inch). In between these two levels, there can be knuckles formed either by MD or CD strands that give the topography a 3-dimensional characteristic; (3) On the top side, the length of the MD knuckles is equal to or longer than the length of the CD knuckles; (4) If the fabric is made in a multi-layer construction, it is preferred that the bottom layer is of a finer mesh than the top layer so as to control the depth of web penetration and to maximize fiber retention; and (5) The fabric may be made to show certain geometric patterns that are pleasing to the eye, which typically repeat between every 2 to 50 warp yarns.

Specific suitable transfer fabrics include, by way of example, those made by Asten Forming Fabrics, Inc., Appleton, Wisconsin and designated as numbers 934, 937, 939 and 959. The void volume of the transfer fabric can be equal to or less than the forming fabric from which the web is transferred.

The speed difference between the forming fabric and the transfer fabric can be from about 5 to about 75 percent or greater, preferably from about 10 to about 35 percent, and more preferably from about 15 to about 25 percent, the transfer fabric being the slower fabric. The optimum speed differential will depend on a variety of factors, including the particular type of product being made. As previously mentioned, the increase in stretch imparted to the web is proportional to the speed differential. For an uncreped throughdried three-ply wiper having a basis weight of about 20 grams per square meter per ply, for example, a speed differential in the production of each ply of from about 20 to about 25 percent between the forming fabric and a sole transfer fabric produces a stretch in the final product of from about 15 to about 20 percent.

The stretch can be imparted to the web using a single differential speed transfer or two or more differential speed transfers of the wet web prior to drying. Hence there can be one or more transfer fabrics. The amount of stretch imparted to the web can hence be divided among one, two, three or more differential speed transfers.

The drying process can be any noncompressive drying method which tends to preserve the bulk or thickness of the wet web including, without limitation, throughdrying, infra-red irradiation, microwave drying, etc. Because of its commercial availability and practicality, throughdrying is a well-known and preferred means for noncompressively drying the web. Suitable throughdrying fabrics include, without limitation, Asten 920A and 937A, and Velostar P800 and

103A. The web is preferably dried to final dryness without creping, since creping tends to lower the web strength.

Because of the smoothness of the web being transferred to the throughdrying fabric, the side of the web not in contact with the throughdrying fabric (the side of the web contacting the transfer fabric) retains its smoothness. Since the differential speed transfer has already occurred and the throughdrying fabric is not involved, there is no need for the web to be pulled deeply into the throughdrying fabric. Nevertheless, the side of the web in contact with the throughdrying fabric substantially conforms to the throughdrying fabric surface, rendering the other side of the web with a more textured macro-pattern. The web consequently has a very two-sided appearance and feel, which is particularly advantageous for multi-ply products where the like sides (preferably the smoother sides) can be plied such that they are outwardly-facing. Alternatively, if desired, the more textured sides can be plied outwardly for improved surface cleaning, or one side of the product can be smooth and the other textured.

Figure 1 is a schematic process flow diagram illustrating a method of making uncreped throughdried sheets in accordance with this invention.

Figure 2 is schematic diagram of the transfer section of the method of Figure 1, illustrating more clearly the fixed gap transfer of the wet web from the forming fabric to the transfer fabric.

Figure 3 is a schematic diagram of the equipment set-up for determining the Surface Smoothness of a sample.

Directing attention to the Drawing, the invention will be described in further detail.

Figure 1 illustrates a means for carrying out the method of this invention. (For simplicity, the various tensioning rolls schematically used to define the several fabric runs are shown but not numbered.) Shown is a papermaking headbox 10 which injects or deposits a stream 11 of an aqueous suspension of papermaking fibers onto the forming fabric 13 which serves to support and carry the newly-formed wet web downstream in the process as the web is partially dewatered to a consistency of about 10 dry weight percent.

After formation, the forming fabric carries the wet web 15 to an optional hydroneedling station 16 where the web can be hydroneedled to increase its bulk. Suitable means for hydroneedling are disclosed in U.S. Patent No. 5,137,600 issued August 11, 1992 to Barnes et al. and entitled "Hydraulically Needled Nonwoven Pulp Fiber Web". Such means provide a multiplicity of pressurized water jets which impinge upon the surface of the newly-formed wet web while supported on the forming fabric, causing an increase in the porosity of the web and hence an increase in bulk.

Whether or not the optional hydroneedling operation is used, additional dewatering of the wet web can be carried out, such as by vacuum suction, while the wet web is supported by the forming fabric. The Fourdrinier former illustrated is particularly useful for making the heavier basis weight sheets useful as wipers and towels, although other forming devices can be used.

The wet web is then transferred from the forming fabric to a transfer fabric 17 travelling at a slower speed than the forming fabric in order to impart increased stretch into the web. Transfer is preferably carried out with the assistance of a vacuum shoe 18 and a fixed gap or space between the forming fabric and the transfer fabric to avoid compression of the wet web.

The wet web is then transferred to a throughdrying fabric 19 travelling at about the same speed, or a different speed if desired, and dried to final dryness as the web is carried over a throughdryer 20.

Prior to being wound onto a reel 21 for subsequent conversion into the final product form, the dried web 22 can be carried through one or more optional fixed gap fabric nips formed between carrier fabrics 23 and 24. The bulk or caliper of the web can be controlled by fabric embossing nips formed between rolls 25 and 26, 27 and 28, and 29 and 30. Suitable carrier fabrics for this purpose are Albany International 84M or 94M and Asten 959 or 937, all of which are relatively smooth fabrics having a fine pattern. Nip gaps between the various roll pairs can be from about 0.00254 to about 0.0508 cm (about 0.001 inch to about 0.02 inch). As shown, the carrier fabric section of the machine is designed and operated with a series of fixed gap nips which serve to control the caliper of the web and can replace or compliment off-line calendering.

Figure 2 more clearly illustrates the transfer fabric section of the process disclosed in Figure 1. Shown is the forming fabric stretched between rolls 31 and 32, between which the wet web 15 leaves the forming fabric and is transferred to the transfer fabric 17. Transfer shoe 18 is provided with a source of vacuum to assist in transferring the wet web to the transfer fabric. The surface of the transfer fabric is relatively smooth in order to provide smoothness to the wet web. The openness of the transfer fabric, as measured by its void volume, can be relatively low and can be about the same as that of the forming fabric or even lower.

As previously mentioned, the transfer fabric is travelling at a slower speed than the forming fabric. The speed differential is preferably from about 20 to about 30 percent, based on the speed of the forming fabric. If more than one transfer fabric is used, the speed differential between fabrics can be the same or different. Multiple transfer fabrics can provide operational flexibility as well as a wide variety of fabric/speed combinations to influence the properties of the final product.

A feature of the transfer fabric section illustrated is the fixed gap between the forming fabric and the transfer fabric at the point of transfer of the web, which coincides with the position of the transfer shoe. The width of the fixed gap is about the thickness of the wet web or even slightly greater in order to avoid or at least minimize compression of the

web during transfer. For a typical wet web having a basis weight of about 20 grams per square meter, the fixed gap will be about 0.0635 cm (about 0.025 inch), but will vary with the amount of stretch imparted to the web since increased stretch results in a greater degree of web expansion at the transfer point. After transfer to the transfer fabric, the web is carried over rolls 33 and 34 and transferred to the throughdrying fabric 19 with the aid of a second vacuum transfer shoe 35, preferably again using a fixed gap transfer as previously described.

The level of vacuum used for the fixed gap transfers can be from about 10159 Pa to about 50795 Pa (from about 76.2 to about 381 mm (about 3 to about 15 inches) of mercury), preferably about 16932 Pa (about 127 mm (about 5 inches) of mercury). The vacuum shoe (negative pressure) can be supplemented or replaced by the use of positive pressure from the opposite side of the web to blow the web onto the next fabric in addition to or as a replacement for sucking it onto the next fabric with vacuum. Also, a vacuum roll or rolls can be used to replace the vacuum shoe(s).

Referring now to Figure 3, the method for determining Surface Smoothness will be described in detail. The Surface Smoothness test measures the smoothness of a surface of a tissue sheet in a way that mimics the response of a human observer gently feeling the surface of the sheet with the fingertips. Either side of the sheet can be measured. The test is based on measurement of the surface profile of a tissue specimen at a nominal angle of 45 degrees with respect to the machine direction of the sheet. The standard deviation of the surface profile is obtained for special frequencies between 0.98 and 8.86 cycles per cm (2.5 and 22.5 cycles per inch) in order to include only those components of surface roughness that are important to human tactile response for tissue, towel or wiper products.

Briefly, the test is based on a surface profile measuring instrument that scans the sheet at a rate of 0.254 cm (0.1 inch) per second with a 50-milligram tracking force placed on a 0.0508 cm (0.020 inch) diameter ball tip stylus. Since the surface topography of any tissue surface has a high degree of variability, the length of the profile scan line should be greater than 25.4 cm (10 inches) to ensure statistically valid results. Since standard profile instruments do not have the capability to scan such large distances, the test is based on an instrument that scans approximately 3.81 cm (1.5 inches). In order to obtain a larger total scan distance, the test specimen is translated in the direction normal to the profile scanning direction within the plane of the test specimen. This sample translation is done at a speed approximately one-fortieth as fast as the profiling instrument scanning rate. This results in the stylus tracing a zig-zag back and forth across the tissue sheet such that a total path of greater than 25.4 cm (10 inches) can be obtained without sampling a given position more than once. The output signal of the profile measuring instrument is passed into a signal analyzer where the amplitude information in the frequency range of interest is extracted. This information is integrated into an RMS average number representing the standard deviation of the signal in the frequency range of interest.

The specific test equipment includes:

1) A Federal Products Corporation (of Providence, Rhode Island) Surfanalyzer System 2000 surface analyzer incorporating a universal probe with a 50-milligram tracking force (part number PMP-31017) coupled to a 0.0508 cm (0.020 inch) ball tip stylus (part number PMP-31132). The probe stylus protector is removed during all testing.

2) A T. S. Products (of Arleta, California) translation table composed of a two-inch translation stage (part number X2), a rotary actuator (part number 1450-2223-548), a controller (part number 1200SC-900), a power supply (part number 1000P) and an interconnecting cable (part number 1200I-10).

3) A Scientific Atlanta, Spectral Dynamics Division (of San Diego, California) model SD380 Signal Analyzer.

Also included is a cable to interconnect the Surfanalyzer with the signal analyzer.

The Surfanalyzer and translation table are mounted on a Newport Corporation (of Fountain View, California) Research Series Table Top (air table) to isolate them from any room floor vibrations. Specifically, the surfanalyzer is set on this table. The probe translation is switched on until the probe is centered in its translation range. Then, the translation table is placed so that its center is directly under the probe tip. The translation table is carefully aligned so that its axis of movement is orthogonal to the axis of movement of the Surfanalyzer probe.

Figure 3 illustrates a schematic diagram of the equipment set-up for measuring the Surface Smoothness of a sample. Shown is the Surfanalyzer control unit 40, the SD 380 Signal Analyzer 41, the Surfanalyzer servo unit 42, the translation arm 43, the probe 44, the stylus tip 45, the tissue sample 46 mounted on a glass slide, the translation table 47 with the direction of movement normal to the face of the page, and connecting cables 48.

The equipment described above must be properly configured in order to obtain valid test results. Each piece of equipment is set as follows:

1) Surfanalyzer - The analyzer is first calibrated with the calibration blocks supplied with the instrument, following the procedures in the equipment manuals. Next, the analyzer is leveled, relative to the translation table, by adjusting the coarse and vernier leveling knobs until the instrument shows level to within 0.254 µm (10 micro-inches) based on a probe scan distance of 3.81 cm (1.5 inches). Finally, the controls are set as follows:

Roughness Cutoff -	Set to 0.0762 cm (0.030 inches);
Traverse Speed -	Set to 0.254 cm (0.1 inches) per second;
Sensitivity -	Set to 5.08 µm (200 micro-inches) per division;
Stylus Travel -	Set for 3.81 cm (1.5 inches) of total;
Limits -	travel centered on the available 5.08 cm (2-inch) range.

2) Translation Table - The speed control is set so that the table moves a distance of 2.286 cm (0.90 inches) in a period of six minutes as measured with an accurate ruler and a stopwatch. The speed control is then kept in that position during all material testing.

3) Signal Analyzer - The analyzer is set up as follows:

400 line baseband single-channel spectrum (giving 1024 time domain points). (Note: the active channel can be set for any of the four available channels as long as the signal cable of the Surfanalyzer is physically coupled to the selected channel);
10 Volt input range with DC coupling;
10 Hz frequency range;
Internal sampling source;
Standard memory operation (NOT extended memory);
"TIME" operating mode with "TIME and SPECTRUM" sub-mode;
"Hz" and "Secs" X axis units with linear scaling;
"Volts" Y axis units with linear scaling and "2X" digital gain;
Dual display mode with upper trace displaying input (time domain) memory and lower trace displaying average spectrum data;
80 dB viewing window;
"Hanning" spectral processing window;
"Data Averager" set for spectral data, "Sum" mode, "Stop on Time" of 120 seconds;
Cursor mode set for "delta P" with a range of 0.25 to 2.25 Hz.

The SD380 signal analyzer has many other "controls", the setting of which is not consequential to this test.

Samples for the Surface Smoothness test must be properly mounted to a glass microscope slide in order to obtain meaningful results. Specifically, samples are placed on a clean Corning Micro-Slide, Number 2947, 7.62 cm by 2.54 cm (3 inch by 1 inch) in size, nominally 1.0 millimeter thick. (These slides are available from Baxter Diagnostics, Inc. of McGaw Park, Illinois). In order to avoid sample slippage, which will invalidate test results, samples are bonded to these slides by the use of 3M Scotch-brand double-coated mylar tape #415. The tape is available from McCaster-Carr Supply Company of Chicago, Illinois). The samples are mounted by the following procedure:

1) Cut a test specimen with dimensions of 15.24 cm by 5.08 cm (6.0 inches by 2.0 inches) such that the longer dimension lies at an angle 45 degrees clockwise with respect to the machine direction of the test material when viewing the sample from the opposite side of the test side;

2) Cut a piece of tape slightly larger than the glass slide with a scissors;

3) Holding a glass slide in one hand, apply the cut tape to the slide starting at one edge and proceeding across the entire surface using a finger to slowly, but firmly, smooth the tape across the slide to avoid wrinkles, air pockets and other imperfections. Such imperfections are clearly visible by looking through the slide during the attachment of the tape. If the adhesive tape does not bond uniformly across the entire surface of the slide, discard the slide;

4) Place the test side of the specimen cut in step 1) down on a clean, smooth table. Peel the backing paper from the tape attached to the glass slide. Lightly press the adhesive covered side of the glass slide down onto the specimen, being sure that the long dimension of the slide is accurately aligned with the long dimension of the cut specimen;

5) After the sample is mounted, carefully cut away adhesive and specimen areas that protrude beyond the edges of the slide, using a razor knife;

6) Finally, inspect the specimen to ensure that no wrinkles or other deformations were caused during the mounting process. Any mounted specimens that show imperfections should be discarded.

Specimens are tested by placing the specimen slide on the translation table with the specimen side up. The slide is aligned so that its longer dimension parallels the probe scanning direction of the Surfanalyzer. It is positioned so that the Surfanalyzer stylus, when fully extended, is positioned about 0.635 cm (about 1/4 inch) from the corner of the specimen slide, towards the center of the slide along the slide diagonal.

Data acquisition on the signal analyzer is started. The Surfanalyzer translation (scanning) motion is switched on and the translation table is started in the direction that moves the centerline of the slide towards the stylus tip. As soon as both motions begin, the Surfanalyzer stylus is adjusted vertically down onto the sample until the signal analyzer time domain display indicates that the signal trace is evenly split about the zero voltage level, indicating nominal centering of the stylus travel within its measurement range. After centering, a delay of 40 seconds is required so that all data acquired during stylus centering is passed from the signal analyzer memory. After 40 seconds, the cleared signal analyzer averager memory is switched on. The averager will run for 120 seconds of spectrum data acquisition, after which time the averager will automatically switch off, indicated by the extinguishing of a panel light. At this point, the translation table and Surfanalyzer translations are switched off and the stylus is raised off the specimen to allow the removal of the slide.

A precursor of the Surface Smoothness value is read off of the signal analyzer spectrum averager by integrating the average spectrum signal from 0.25 to 2.25 Hz using the "delta P" cursor mode. The "delta P" mode integrates the square of the displayed magnitude spectra to give the RMS "power" within the frequency range of interest. The output units are volts.

The numbers off the signal analyzer must be multiplied by the ratio of micro-inches of stylus displacement per volt of output of the Surfanalyzer to convert to units of μm (micro-inches). When the Surfanalyzer is operated on the 5.08 μm (200 micro-inch) per division sensitivity range, the auxiliary output voltage represents 40.64 μm (1600 micro-inches) per volt. Therefore, the "delta P" value is multiplied by 1600 to convert the units from volts to micro-inches.

Since the mean translation speed of the probe is approximately 0.254 cm (approximately 0.1 inches) per second (the translation table velocity component being so low as to be of no consequence to the total velocity), the temporal frequency range of 0.25 Hz to 2.25 Hz corresponds to a spacial frequency of 0.98 to 8.86 cycles per cm (2.5 to 22.5 cycles per inch). The Surface Smoothness value is therefore equivalent to the frequency partitioned standard deviation of the specimen surface profile between the frequencies of 0.98 and 8.86 cycles per cm (2.5 and 22.5 cycles per inch).

In order to obtain meaningful test results, at least five, and preferably ten, specimens should be tested for each sheet sample side.

Examples

Example 1 (This invention). In order to further illustrate the invention, an uncreped throughdried web was made using the method illustrated in Figure 1. More specifically, an aqueous suspension of 100% secondary papermaking fibers was prepared containing about 0.2 weight percent fibers. The fiber suspension was fed to a Fourdrinier headbox and deposited onto the forming fabric. The forming fabric was an Asten 866 having a void volume of 64.5%. The speed of the forming fabric was 262.7 m per minute (862 feet per minute). The newly-formed web was dewatered to a consistency of about 20 weight percent using vacuum suction from below the forming fabric before being transferred to the transfer fabric, which was travelling at a speed of about 228.6 m per minute (about 750 feet per minute) (15% differential speed). The transfer fabric was an Asten 959 having a void volume of 59.9%. A fixed gap of about 0.635 millimeter was maintained between the forming fabric and the transfer fabric at the point of transfer, the fixed gap being slightly wider than the thickness of the wet web at that point in the process to allow for sheet expansion while transferring. A vacuum shoe pulling a vacuum of 127 mm (5 inches) of mercury was used to make the transfer without compacting the wet web. The web was then transferred to a 920A throughdrying fabric travelling at a speed of 228.6 m per minute (750 feet per minute). The web was carried over a Honeycomb throughdryer operating at a temperature of about 176.67°C (about 350°F). and dried to final dryness (about 2 percent moisture). The resulting basesheet was wound into a softroll and exhibited the following properties: basis weight, 22 grams per square meter (gsm); geometric mean tensile strength, 2188 grams per 7.62 cm (3 inches) width (grams); and Surface Smoothness, 78.99 μm (3110 micro-inches).

Example 2 (This invention). An uncreped throughdried sheet was made as described in Example 1, except that the speed of the forming fabric was 246.89 m per minute (810 feet per minute) (8% speed differential). The resulting properties of the basesheet were as follows: basis weight, 21 gsm; geometric mean tensile strength, 1476 grams; and Surface Smoothness, 60.706 μm (2390 micro-inches).

Example 3 (This invention). An uncreped throughdried sheet was made as described in Example 1, except that the newly-formed sheet was hydroneedled to improve the absorbent wicking of the sheet. The properties of the resulting sheet were as follows: basis weight, 22 gsm; geometric mean tensile strength, 1901 grams; and Surface

Smoothness, 81.534 μm (3210 micro-inches).

Example 4 (This invention). An uncreped throughdried sheet was made as described in Example 2, except the newly-formed web was hydroneedled as previously described. The properties of the resulting sheet were as follows: basis weight, 21 gsm; geometric mean tensile strength, 1476 grams; and Surface Smoothness, 60.706μm (2390 micro-inches).

Example 5. For comparison, an uncreped throughdried sheet was made similarly as described in Example 1, but without a transfer fabric and without a fixed gap transfer. Instead, the transfer fabric was replaced with a typical throughdryer fabric (Asten 920A) and the differential speed relative to the forming fabric was 20% slower. The resulting web had the following properties: basis weight, 16 gsm; geometric mean tensile strength, 2056 grams; and Surface Smoothness, 88.138 μm (3470 micro-inches). A repeat of Example 5 yielded a Surface Smoothness of 85.344 μm (3360 micro-inches).

As shown by the previous Examples, the use of a transfer fabric as herein defined can produce a smoother sheet as evidenced by the Surface Smoothness.

Claims

1. A method of making a cellulosic web comprising:
depositing an aqueous suspension of papermaking fibers onto the surface of an endless travelling foraminous forming fabric to form a wet web having a consistency of from 15 to 25 percent; transferring the wet web from the forming fabric to a first transfer fabric travelling at a speed slower than the forming fabric;
characterized by

    transferring the wet web from the first transfer fabric optionally via at least one further transfer fabric to a drying fabric, whereon the web is noncompressively dried;

    whereby the wet web is transferred from the forming fabric to the first transfer fabric with a fixed gap between the forming fabric and the first transfer fabric, the fixed gap having a span equal to or greater than the thickness of the web leaving the forming fabric, whereby the wet web is not compressed during the transfer; and

    whereby said first transfer fabric preferably travels at a speed of 5 to 75 percent slower than the forming fabric.

2. The method of Claim 1 wherein the drying fabric is a throughdrying fabric and the web is throughdried.

3. The method of Claim 2 wherein the throughdried web is transferred from the throughdrying fabric to a relatively smooth carrier fabric and thereafter compressed in a fixed gap between the carrier fabric and another relatively smooth fabric to control and reduce the caliper of the dried web.

4. The method of Claim 2 or 3 wherein the throughdried web is compressed in two or more fixed gaps, each successive fixed gap being smaller than the previous fixed gap.

5. The method of Claim 2, 3 or 4 wherein the throughdried web is compressed in three or more fixed gaps.

6. The method of any one of the preceding claims wherein the wet web is transferred from the first transfer fabric to a second transfer fabric prior to throughdrying.

7. The method of Claim 6 wherein the second transfer fabric is travelling at a slower speed than the first transfer fabric.

8. The method of any one of the preceding claims wherein the transfer of the web from the first transfer fabric to the throughdrying fabric is carried out with a fixed gap between the transfer fabric and the throughdrying fabric, the fixed gap having a span equal to or greater than the thickness of the web leaving the transfer fabric, whereby the web is not compressed during the transfer.

9. A method of making a cellulosic web comprising:
transferring the wet web from a forming fabric to a drying fabric, travelling at a speed slower than the forming fabric

and noncompressively drying the web;
characterized by

maintaining a fixed gap between the forming fabric and the drying fabric, wherein the fixed gap between the forming fabric and the drying fabric has a span equal to or greater than the thickness of the web leaving the forming fabric,

whereby the drying fabric is travelling at a speed of from 5 to 75 percent slower than the forming fabric.

Patentansprüche

1. Verfahren zur Herstellung einer Zellulosebahn, das folgendes umfaßt:
Ablegen einer wäßrigen Suspension aus Fasern zur Papierherstellung auf die Oberfläche eines endlosen, sich bewegenden, mit Löchern versehenen Formgewebes zur Bildung einer nassen Bahn mit einer Konsistenz von 15 bis 25 Prozent; Übertragen der nassen Bahn von dem Formgewebe zu einem ersten Übertragungsgewebe, welches sich mit einer langsameren Geschwindigkeit als das Formgewebe bewegt;
gekennzeichnet durch

   Übertragen der nassen Bahn von dem ersten Übertragungsgewebe wahlweise über mindestens ein weiteres Übertragungsgewebe zu einem Trocknungsgewebe, worauf die Bahn drucklos getrocknet wird;

   wodurch die nasse Bahn mit einem festen Spalt zwischen dem Formgewebe und dem ersten Übertragungsgewebe von dem Formgewebe zu dem ersten Übertragungsgewebe übertragen wird, wobei der feste Spalt eine Spannweite aufweist, welche im Vergleich zur Dicke der das Formgewebe verlassenden Bahn gleich oder größer ist, wobei die nasse Bahn während der Übertragung nicht zusammengedrückt wird; und

   wobei das erste Übertragungsgewebe sich vorzugsweise mit einer Geschwindigkeit bewegt, welche im Vergleich zum Formgewebe 5 bis 75 Prozent langsamer ist.

2. Verfahren gemäß Anspruch 1, bei dem das Trocknungsgewebe ein Durchlufttrocknungsgewebe ist und die Bahn durchluftgetrocknet wird.

3. Verfahren gemäß Anspruch 2, bei dem die durchluftgetrocknete Bahn von dem Durchlufttrocknungsgewebe zu einem relativ glatten Trägergewebe übertragen wird und danach in einem festen Spalt zwischen dem Trägergewebe und einem anderen relativ glatten Gewebe zusammengedrückt wird, um die Dicke der getrockneten Bahn zu kontrollieren und zu reduzieren.

4. Verfahren gemäß Anspruch 2 oder 3, bei dem die durchluftgetrocknete Bahn in zwei oder mehr festen Spalten zusammengedrückt wird, wobei jeder feste Spalt kleiner als der vorhergehende feste Spalt ist.

5. Verfahren gemäß Anspruch 2, 3 oder 4, bei dem die durchluftgetrocknete Bahn in drei oder mehreren festen Spalten zusammengedrückt wird.

6. Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem die nasse Bahn vor dem Durchlufttrocknen von dem ersten Übertragungsgewebe zu einem zweiten Übertragungsgewebe übertragen wird.

7. Verfahren gemäß Anspruch 6, bei dem das zweite Übertragungsgewebe sich mit einer niedrigeren Geschwindigkeit als das erste Übertragungsgewebe bewegt.

8. Verfahren gemäß einem der vorhergehenden Ansprüche, bei dem die Übertragung der Bahn von dem ersten Übertragungsgewebe zu dem Durchlufttrocknungsgewebe mit einem festen Spalt zwischen dem Übertragungsgewebe und dem Durchlufttrocknungsgewebe erfolgt, wobei der feste Spalt eine Spannweite aufweist, welche im Vergleich zur Dicke der das Übertragungsgewebe verlassenden Bahn gleich oder größer ist, wobei die Bahn während der Übertragung nicht zusammengedrückt wird.

9. Verfahren zur Herstellung einer Zellulosebahn, das folgendes umfaßt:
Übertragen der nassen Bahn von einem Formgewebe zu einem Trocknungsgewebe, welches sich mit einer lang-

sameren Geschwindigkeit als das Formgewebe bewegt, und druckloses Trocknen der Bahn;
gekennzeichnet durch

Aufrechterhalten eines festen Spalts zwischen dem Formgewebe und dem Trocknungsgewebe, wobei der feste Spalt zwischen dem Formgewebe und dem Trocknungsgewebe eine Spannweite aufweist, welche im Vergleich zur Dicke der das Formgewebe verlassenden Bahn gleich oder größer ist,

wobei das Trocknungsgewebe sich mit einer Geschwindigkeit bewegt, welche im Vergleich zum Formgewebe 5 bis 75 Prozent langsamer ist.

Revendications

1. Procédé de fabrication d'une nappe cellulosique comprenant :
le dépôt d'une suspension aqueuse de fibres papetières sur la surface d'une toile de formation perforée se déplaçant en continu, pour former une nappe humide ayant une concentration comprise entre 15 et 25% ; le transfert de la nappe humide depuis la toile de formation jusqu'à une première toile de transfert se déplaçant à une vitesse plus faible que la toile de formation ;
caractérisé par

le transfert de la nappe humide depuis la première toile de transfert, éventuellement via au moins une autre toile de transfert, jusqu'à une toile de séchage sur laquelle la nappe est séchée sans compression ;
de telle manière que la nappe humide est transférée depuis la toile de formation jusqu'à la première toile de transfert avec un interstice fixe entre la toile de formation et la première toile de transfert, lequel interstice fixe a une étendue égale ou supérieure à l'épaisseur de la nappe quittant la toile de formation, de sorte que la nappe humide n'est pas comprimée au cours du transfert ; et
de telle manière que ladite première toile de transfert se déplace de préférence à une vitesse qui est de 5 à 75% plus faible que celle de la toile de formation.

2. Procédé selon la revendication 1, dans lequel la toile de séchage est une toile de séchage par soufflage transversal et la nappe est séchée par soufflage transversal.

3. Procédé selon la revendication 2, dans lequel la nappe séchée par soufflage transversal est transférée depuis la toile de séchage par soufflage transversal jusqu'à une toile support relativement lisse, puis comprimée dans un interstice fixe entre la toile support et une autre toile relativement lisse pour maîtriser et réduire l'épaisseur de la nappe séchée.

4. Procédé selon la revendication 2 ou 3, dans lequel la nappe séchée par soufflage transversal est comprimée dans deux interstices fixes ou davantage, chacun des interstices fixes successifs étant plus petit que l'interstice fixe précédent.

5. Procédé selon la revendication 2, 3 ou 4, dans lequel la nappe séchée par soufflage transversal est comprimée dans trois interstices fixes ou davantage.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel la nappe humide est transférée depuis la première toile de transfert jusqu'à une seconde toile de transfert avant le séchage par soufflage transversal.

7. Procédé selon la revendication 6, dans lequel la seconde toile de transfert se déplace à une vitesse plus faible que la première toile de transfert.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel le transfert de la nappe depuis la première toile de transfert jusqu'à la toile de séchage par soufflage transversal est effectué en prévoyant un interstice fixe entre la toile de transfert et la toile de séchage par soufflage transversal, l'interstice fixe ayant une étendue égale ou supérieure à l'épaisseur de la nappe quittant la toile de transfert, de sorte que la nappe n'est pas comprimée au cours du transfert.

9. Procédé de fabrication d'une nappe cellulosique comprenant : le transfert de la nappe humide depuis une toile de

formation jusqu'à une toile de séchage qui se déplace à une vitesse plus faible que la toile de formation, et le séchage sans compression de la nappe ;

caractérisé par

le maintien d'un interstice fixe entre la toile de formation et la toile de séchage, lequel interstice fixe entre la toile de formation et la toile de séchage a une étendue égale ou supérieure à l'épaisseur de la nappe quittant la toile de formation,
de sorte que la toile de séchage se déplace à une vitesse qui est de 5 à 75% plus faible que celle de la toile de formation.

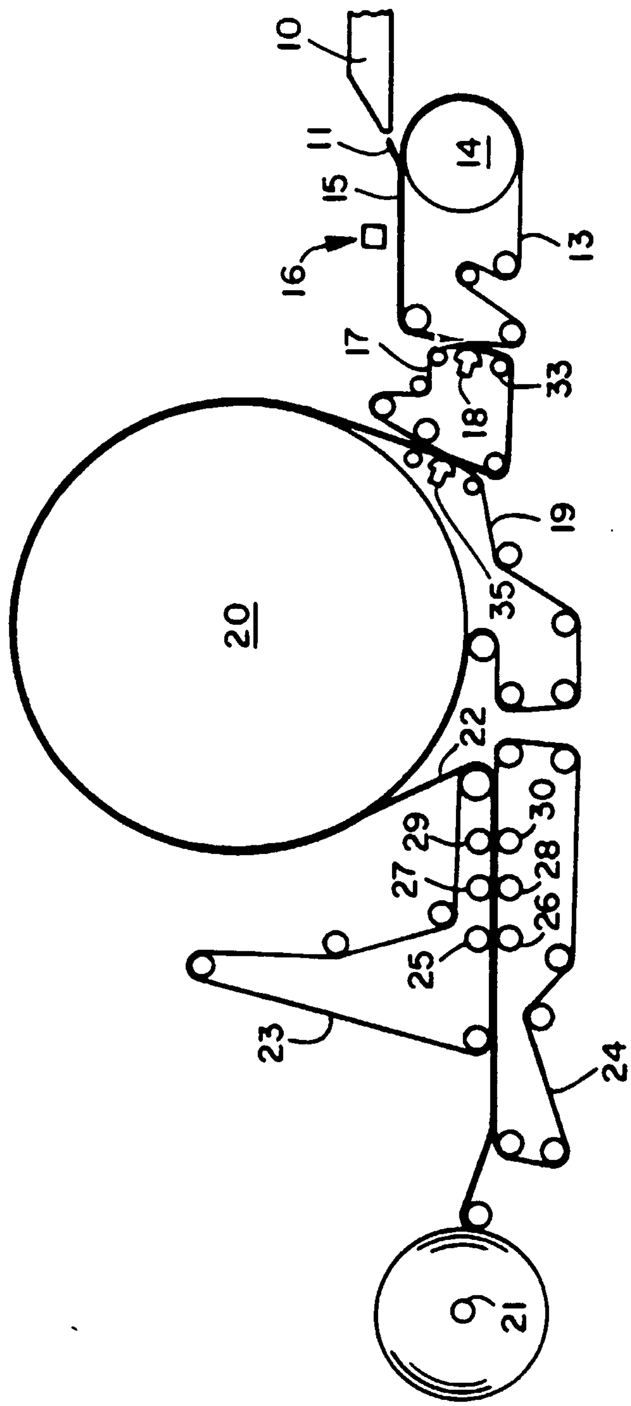

FIG. 1

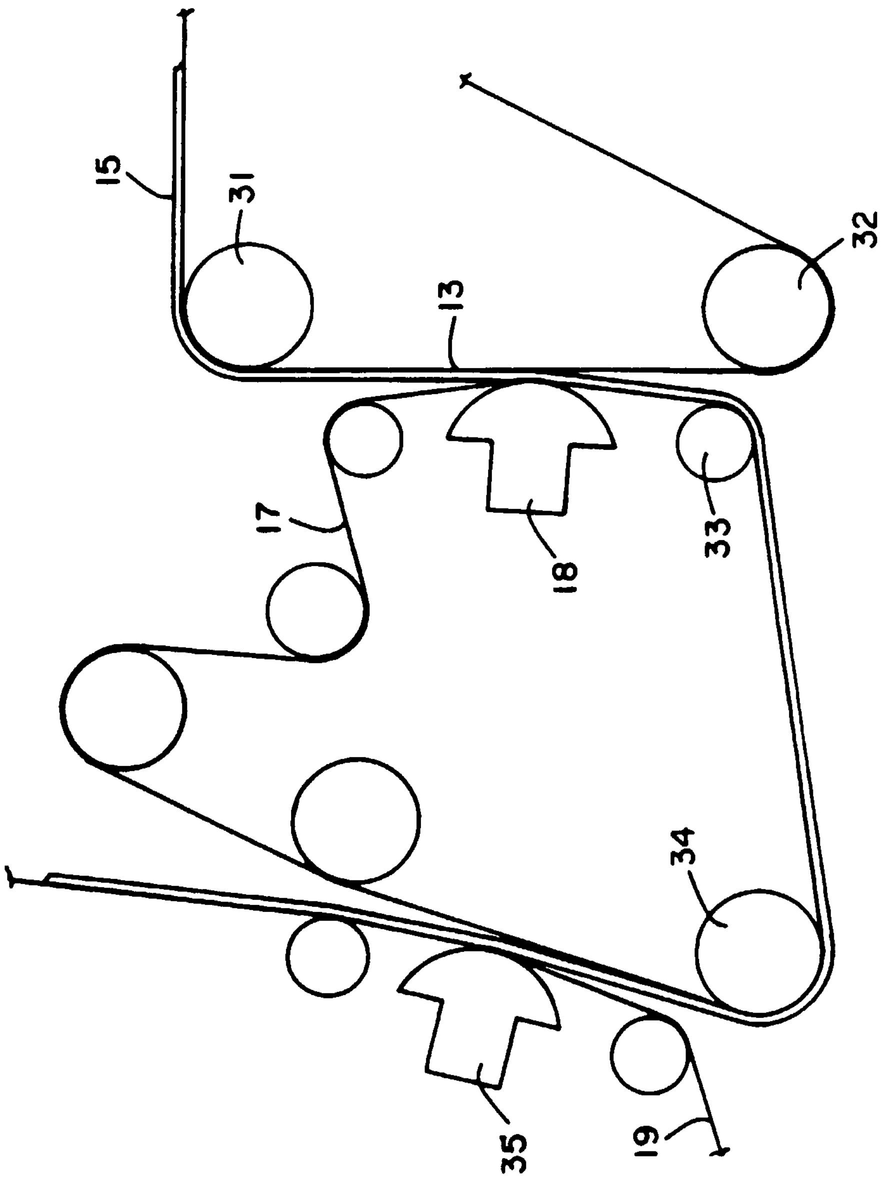

FIG. 2

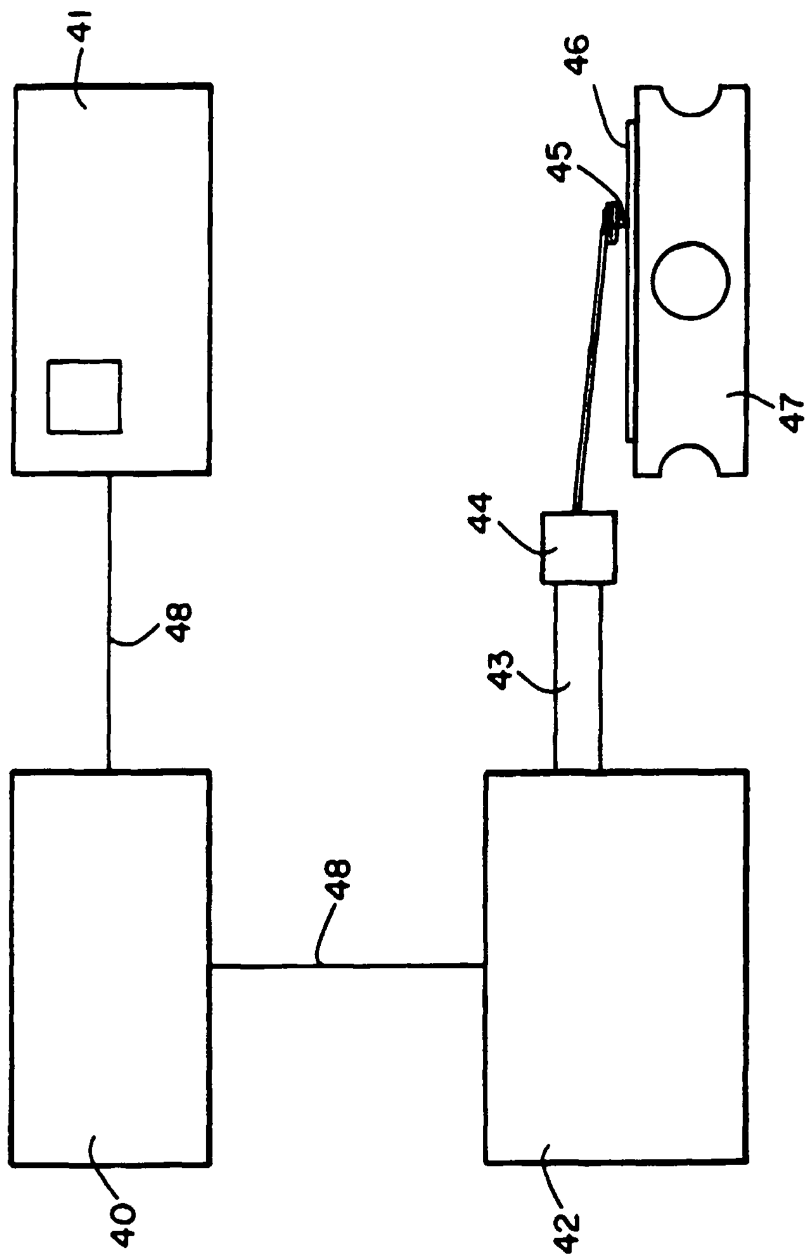

FIG. 3